YECSIM Model in GRA

Yukon Utilities Board

February 12, 2018

YUKON ENERGY

Overview of Presentation

1. Context for YECSIM in 2017/18 GRA
2. Fundamentals of YECSIM – User Manual
3. Application of YECSIM in 2017/18 GRA

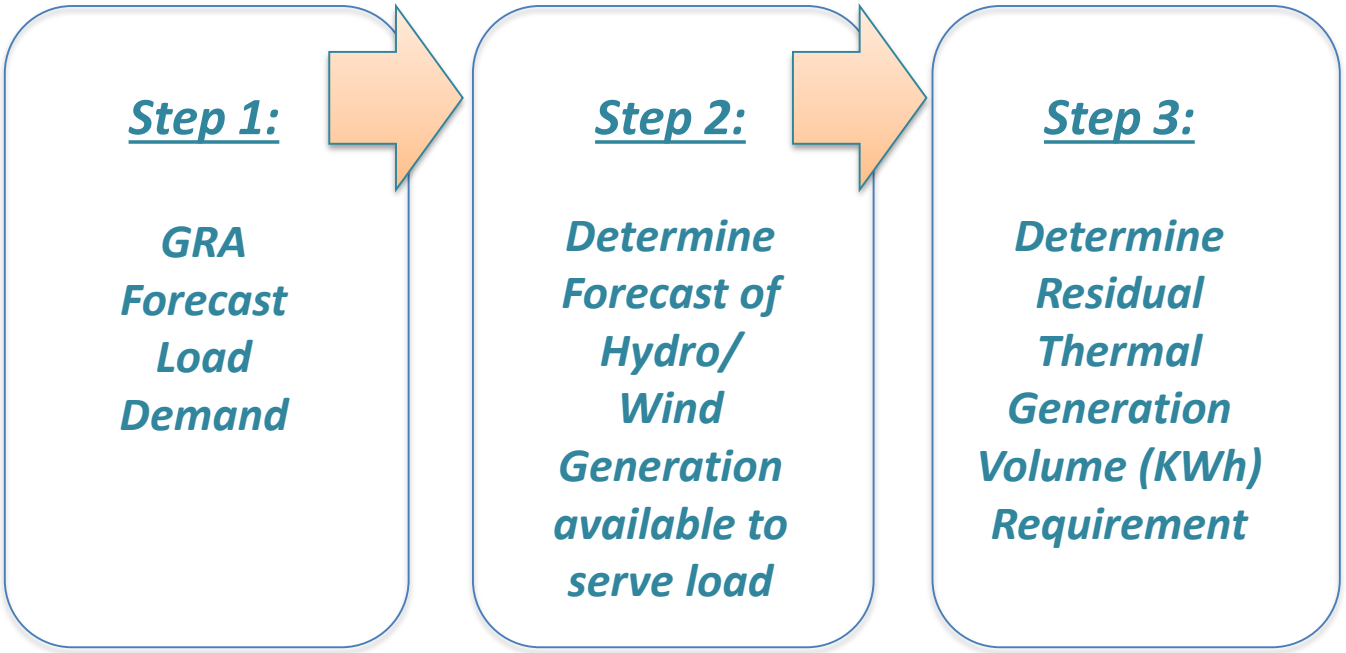
Context for YECSIM in 2017/18 GRA

Context for YECSIM in 2017/18 GRA

- ✓ YECSIM results used for :
  - o GRA thermal forecast for test years
  - o DCF year end determinations (for rate stabilization purposes)
  - o Business case based on LTA Hydro
- ✓ As this is GRA focused discussion – comments are focused on #1 and #2 above

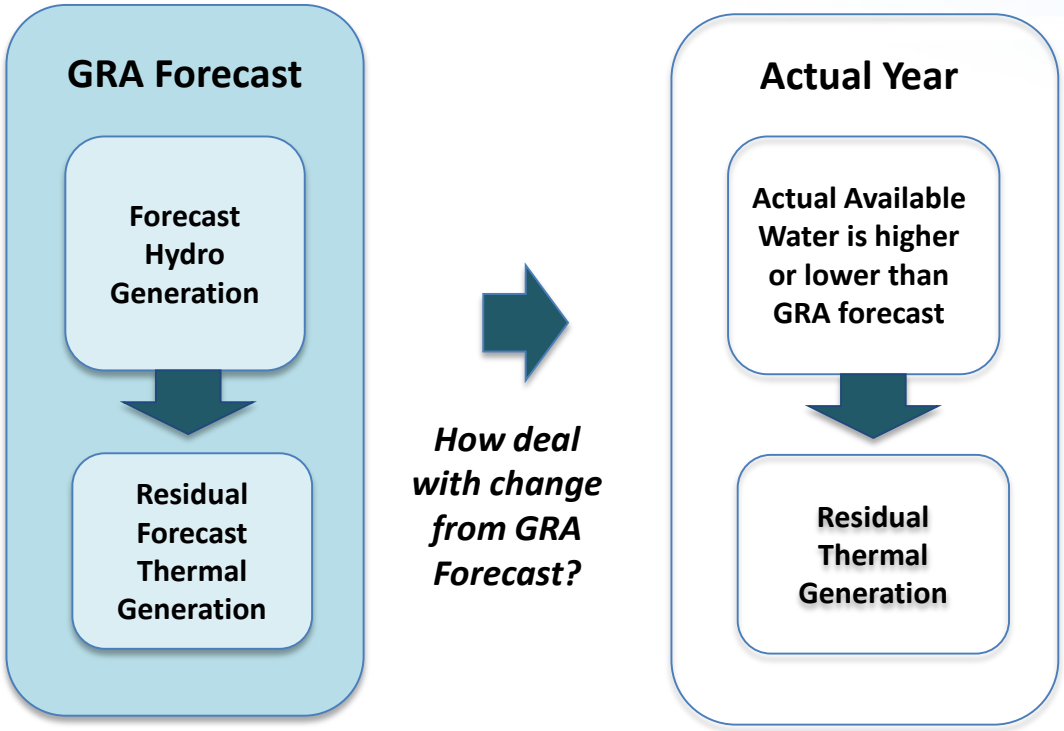
Context for YECSIM in 2017/18 GRA
Water-Related & Thermal Generation Forecasts

- ✓ A GRA requires a **thermal generation forecast**
- ✓ The **thermal generation forecast** depends on the **hydro generation forecast**, which is affected by forecast water



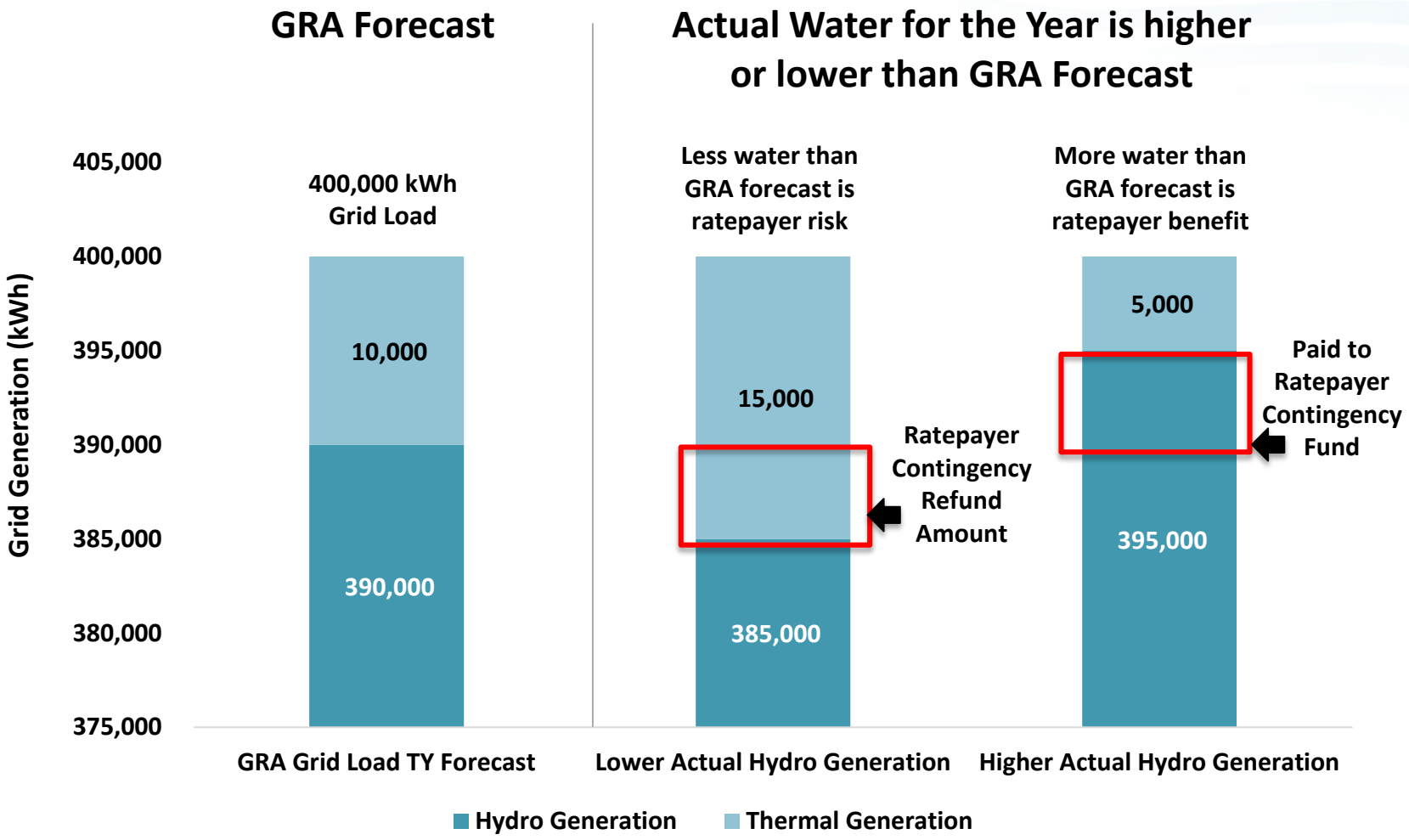
Context for YECSIM in 2017/18 GRA
Water-Related & Thermal Generation Forecasts

- ✓ Change in water from GRA forecast is a ratepayer risk
- ✓ Need to assess at the end of each fiscal year
- ✓ Determines YEC's thermal costs for its accounts



Context for YECSIM in 2017/18 GRA

Water-Related & Thermal Generation Forecasts



Context for YECSIM in 2017/18 GRA
Generation Forecast Methods Can Vary

- ✓ *Forecast methods can vary*
- ✓ *Regardless of forecast used, need consistent implementation in GRA and for determining diesel generation costs at each year end*

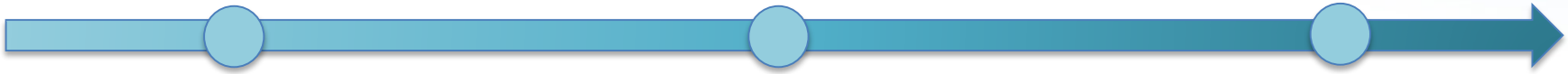
Short Term Forecast

- *Looks at actual water available*
- *Greater rate instability*

Long Term Average Forecast

- *Expected hydro/ thermal over range of conditions*
- *Promotes rate stability/ intergenerational equity*

History Leading to YECSIM in 2017/18 GRA



1990's
Faro Mine Operation "on" & "off"

- ✓ Simple "on" and "off" "diesel on margin" rules depending on whether Faro mine operating
- ✓ GRAs shift from ST to LTA forecasts with ratepayer contingency funds
- ✓ Diesel Contingency Fund (DCF) established

1998-2011
Faro Mine "off" permanently

- ✓ Diesel generation not responsive to load changes under LTA hydro conditions
- ✓ DCF suspended

2012/13 GRA
Load Growth & diesel at LTA

- ✓ Load growth results in resumption of DCF operation
- ✓ LTA hydro adopted and approved for GRA purposes
- ✓ YECSIM used to determine LTA – varies with load (not simple "on and "off" assessment)

Conclusion re: YECSIM in 2017/18 GRA

- ***LTA in GRA forecast***
  - Since mid 90's, LTA is accepted as determinative for YEC thermal requirements
  - In 2012/13, YUB approved LTA as determined by YECSIM model
- ***LTA thermal generation for accounting at each year end***
  - Based on actual load, YECSIM results determines difference in thermal generation which leads to actual fuel expense and transfer to/from DCF
  - The DCF is the ratepayer stabilization mechanism

Fundamentals of YECSIM

Fundamentals of YECSIM

- Model overview
- User Manual structure
- Methodology
- Inputs
- Outputs

Fundamentals of YECSIM

Model overview

Appendix 2.4 of December 6/17 Two-Part ERA Application

- ✓ Simulation model that estimates hydro and thermal generation
  - o Determines LTA hydro and thermal generation (GRA role)
  - o Developed by the KGS Group in 2008
- ✓ Scenario based model
  - o Range of recorded water inflows and future load
- ✓ Rule based model
  - o Water-related license conditions
  - o Plan specific constraints (e.g. Mayo Lake outlet restriction, downstream icing)
  - o Rules to maximize use of water, minimize use of thermal
- ✓ User Manual
  - o Provided to facilitate testing of YECSIM by interveners and the Board

Fundamentals of YECSIM

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Fundamentals of YECSIM
User Manual Structure

Key Sections of Manual for understanding YECSIM:

Key Sections of Manual

1.0 Introduction

- ✓ Overview of model

4.0 Input

- ✓ Review of model inputs

5.0 Output

- ✓ Review of model outputs

6.0 Program Theory

- ✓ Section 6.1 review of modelling strategy & assumptions

Appendices [model input details]

Appendix A: Format of Input Files

Appendix B: Reservoir Rule Curves

Appendix C: Program Flowcharts

Appendix D: Tables of Input Parameters

Appendix E: Licenses for YEC Reservoirs & Plants

Note: Remaining sections of the User Manual are mainly for operators, e.g., sections 2 and 3 on installing and working with YECSIM graphical interface, section 7 on earlier example simulations, and section 8 tips on program application and problem avoidance

Fundamentals of YECSIM

User Manual Status

- ✓ **User Manual Status:**
  - Developed in 2009, updated in 2017
  - LTA wind is removed from load used for YECSIM simulation
  - YECSIM does not separate diesel vs. LNG thermal

Fundamentals of YECSIM

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Fundamentals of YECSIM Methodology

User Manual sections 1 and 6.1.1 to 6.1.5

- ✓ Address single load scenario for one load year – weekly time steps
  - o Total annual demand distributed by week over entire year.
  - o Weekly time steps chosen to balance various factors (p106).
- ✓ Creates combinations of historical inflows over repeated load (load years (User Manual 8 load years being)
  - o Water years - historic lake inflows
  - o Cycle - a combination of water years over load years
  - o The number of cycles equals the number of water years.
- ✓ Calculates average over all of the cycles

Fundamentals of YECSIM

Methodology

	Load	Load	Load	Load	Load	Load	Load	Load
Sequence 1	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7	Inflow 8

OUTPUT	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**

Fundamentals of YECSIM

Methodology

	Load	Load	Load	Load	Load	Load	Load	Load	Load
Sequence 1	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7	Inflow 8	
Sequence 2		Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7	Inflow 8

OUTPUT	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	

Fundamentals of YECSIM

Methodology

	Load	Load	Load	Load	Load	Load	Load	Load
Sequence 1	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7	Inflow 8
Sequence 2	Inflow 8	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7

OUTPUT	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**

Fundamentals of YECSIM

Methodology

	Load	Load	Load	Load	Load	Load	Load	Load	Load
Sequence 1	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7	Inflow 8	
Sequence 2	Inflow 8	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7	
Sequence 3		Inflow 8	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7

OUTPUT	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**

Fundamentals of YECSIM

Methodology

	Load	Load	Load	Load	Load	Load	Load	Load
Sequence 1	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7	Inflow 8
Sequence 2	Inflow 8	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7
Sequence 3	Inflow 7	Inflow 8	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6

OUTPUT	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**

Fundamentals of YECSIM

Methodology

	Load	Load	Load	Load	Load	Load	Load	Load
Sequence 1	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7	Inflow 8
Sequence 2	Inflow 8	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7
Sequence 3	Inflow 7	Inflow 8	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6
Sequence 4	Inflow 6	Inflow 7	Inflow 8	Inflow 1	Inflow 2	Inflow 3	Inflow 4	Inflow 5
Sequence 5	Inflow 5	Inflow 6	Inflow 7	Inflow 8	Inflow 1	Inflow 2	Inflow 3	Inflow 4
Sequence 6	Inflow 4	Inflow 5	Inflow 6	Inflow 7	Inflow 8	Inflow 1	Inflow 2	Inflow 3
Sequence 7	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7	Inflow 8	Inflow 1	Inflow 2
Sequence 8	Inflow 2	Inflow 3	Inflow 4	Inflow 5	Inflow 6	Inflow 7	Inflow 8	Inflow 1
OUTPUT	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**	**Average**

Fundamentals of YECSIM

Methodology

	Load Year 1	Load Year 2	Load Year 3	Load Year 4	Load Year 5	Load Year 6	Load Year 7	Load Year 8
Cycle 1	Water Year 1	Water Year 2	Water Year 3	Water Year 4	Water Year 5	Water Year 6	Water Year 7	Water Year 8
Cycle 2	Water Year 8	Water Year 1	Water Year 2	Water Year 3	Water Year 4	Water Year 5	Water Year 6	Water Year 7
Cycle 3	Water Year 7	Water Year 8	Water Year 1	Water Year 2	Water Year 3	Water Year 4	Water Year 5	Water Year 6
Cycle 4	Water Year 6	Water Year 7	Water Year 8	Water Year 1	Water Year 2	Water Year 3	Water Year 4	Water Year 5
Cycle 5	Water Year 5	Water Year 6	Water Year 7	Water Year 8	Water Year 1	Water Year 2	Water Year 3	Water Year 4
Cycle 6	Water Year 4	Water Year 5	Water Year 6	Water Year 7	Water Year 8	Water Year 1	Water Year 2	Water Year 3
Cycle 7	Water Year 3	Water Year 4	Water Year 5	Water Year 6	Water Year 7	Water Year 8	Water Year 1	Water Year 2
Cycle 8	Water Year 2	Water Year 3	Water Year 4	Water Year 5	Water Year 6	Water Year 7	Water Year 8	Water Year 1
LTA = Average of Yr 6 & Yr 7	**Average LY1**	**Average LY2**	**Average LY3**	**Average LY4**	**Average LY5**	**Average LY6**	**Average LY7**	**Average LY8**

Fundamentals of YECSIM

- Model overview
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Fundamentals of YECSIM Inputs

User Manual sections 4, 6.1 and Appendices

Section 4

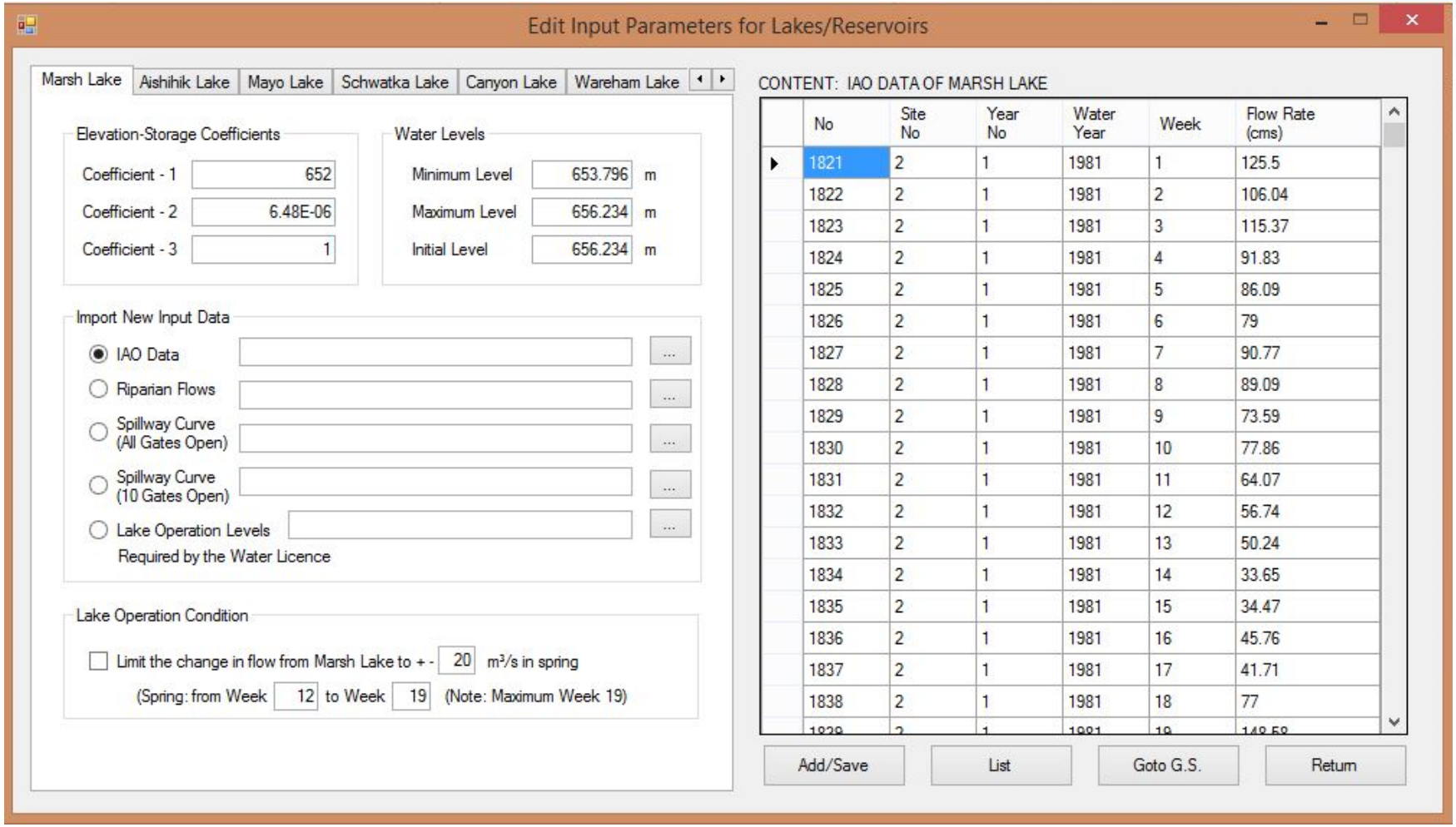
- Overview of 18 data types under 3 headings:
  - ✓ For Lakes
  - ✓ For Generating Stations
  - ✓ For Load Forecast

Section 6 & Appendices

- Section 6.1.3 – Inflows-Available-for Outflow (IAO)
- Sections 6.1.6 to 6.1.16 review various specific inputs
  - ✓ ***Appendix D*** – Tables of Input Parameters
  - ✓ ***Reservoir Rule Curves & Stacking*** – Section 6.1.11 and 6.1.14 and Appendix B [excerpt from textbook)
  - ✓ ***License Limitations for Reservoirs and Plants –*** Section 6.1.16 and Appendix E [copy of each current YEC Water License]

Fundamentals of YECSIM Inputs

Example of Marsh Lake



Fundamentals of YECSIM

Major Inputs for 2017/18 GRA

Water Record

- ✓ Historic inflows 35 years from 1981 to 2015
- ✓ Goal is to include variety of water conditions
  - o Floods, droughts, average

System Capability

- ✓ Generating station capacity & performance data
- ✓ Generation dispatch order [maximize use of water; minimize diesel]
- ✓ Licenced operating conditions

Load Forecast

- ✓ Load Forecast per GRA for 2017 and 2018

Fundamentals of YECSIM

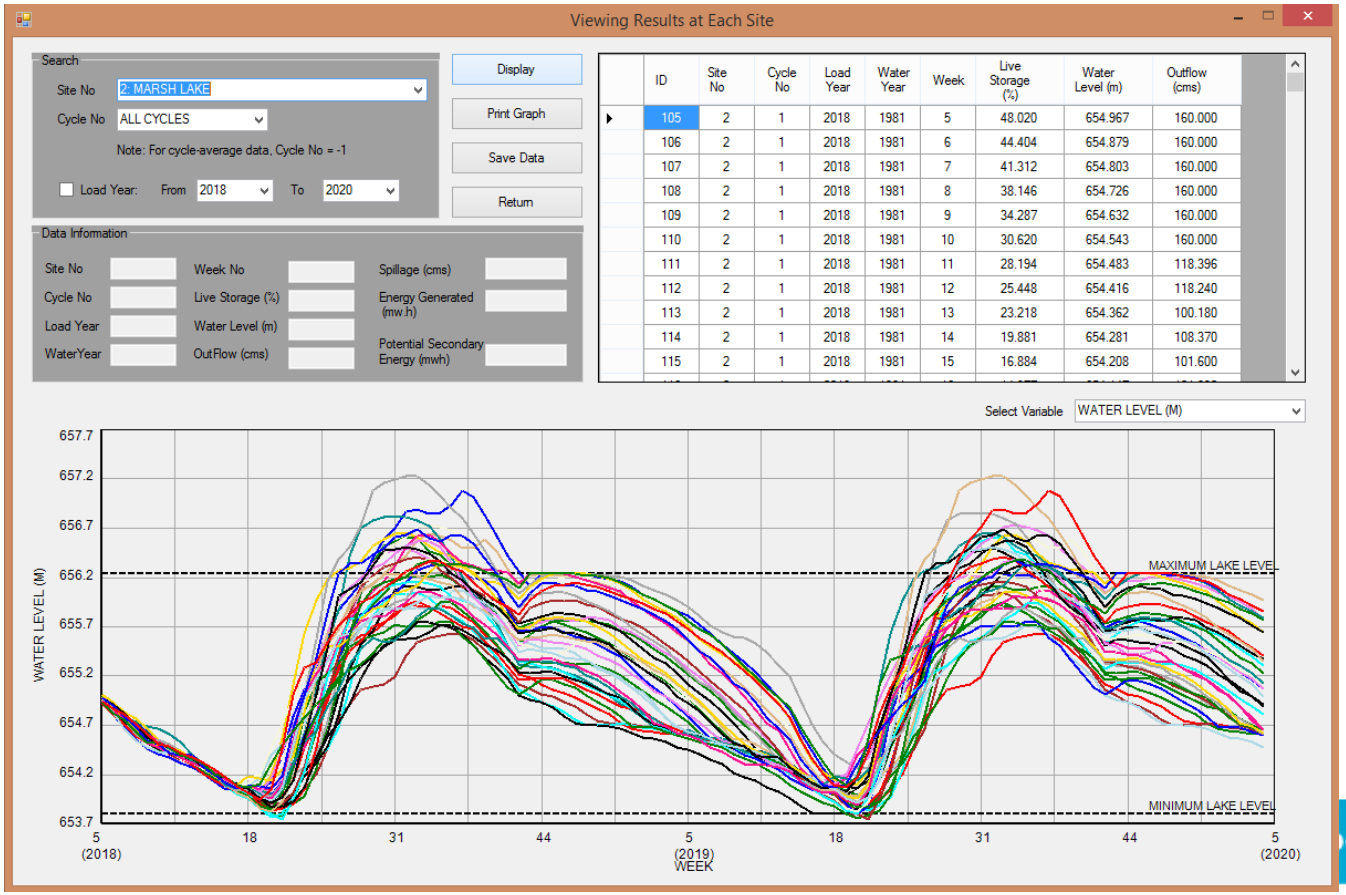
- Model overview
- User manual structure
- Methodology
- Inputs
- Outputs

Fundamentals of YECSIM

Major Outputs

User Manual Section 5.1 and 5.2

- ✓ Wide range of potential outputs identified in section 5.2



Fundamentals of YECSIM

Major Outputs – 2017/18 GRA

2017/18 GRA Simulations

- ✓ User Manual has earlier number of load years (8) for simulations
  - o Reviews how LTA based in initial YECSIM runs on 2 load years (yrs 6-7)
- ✓ YECSIM simulations use 20 load years for analysis
  - o The first 6 load year simulations [years 1-6] *&* last load year simulation [Year 20] are removed from the averaging for LTAs
- ✓ 2017/18 GRA uses 35 water years
  - o Each cycle begins with the next consecutive water year, e.g., Cycle 1: 1981-2000; Cycle 2: 1982 – 2001; Cycle 3: 1983-2002
  - o Each cycle includes 20 load years (total of 700 simulations)
  - o LTA calculated for 13 load years (year 7-19) in each of the 35 cycles

Fundamentals of YECSIM

LTA Calculation – 2017/18 GRA for each test year load forecast

35 Cycles	Water Years [1981-2015]
1	1981
2	1982
3	1983
4	1984
5	1985
.	.
.	.
.	.
.	.
.	.
34	2014
35	2015

"Load Years" used to calculate LTA by week

Cycles	*20 water years included in "load year" each cycle [700 separate simulations]*
1	20 Years [1981, 1982.....1999, 2000]
2	20 Years [1982, 1983.....2000, 2001]
3	20 Years [1983, 1984.....2001, 2002]
4	20 Years [1984, 1985.....2002, 2003]
5	20 Years [1985, 1986.....2003, 2004]
.	.
.	.
.	.
.	.
.	.
34	20 Years [2014, 2015.....1997, 1998]
35	20 Years [2015, 1981.....1998, 1999]

- *LTA calculation removes Load Years 1-6 and Year 20*
- *Load Years 7-19 used to calculate LTA*
- *35 Cycles x 13 Load Years = 455 simulations used to calculate LTA*

Application of YECSIM in 2017/18 GRA

Application of YECSIM in 2017/18 GRA
Updates to YECSIM [Appendix 3.4 of GRA]

- ✓ Updated Assumptions on YECSIM for this GRA included in Appendix 3.4 of GRA [see App 3.4, section 1.2]:

Additional Water Year Records

- 2012/13 GRA used 28 water years [1981-2008]
- 2017/18 GRA uses 35 water years [1981-2015]

Recent Major System Changes

- CSTP, Mayo B
- Aishihik 3rd Turbine

Changes re: Constraints

- Mayo Lake Outlet Channel constraints
- Mayo GS winter outflows due to downstream icing issues

Application of YECSIM in 2017/18 GRA

- ***2017/18 GRA Forecast*** uses LTA hydro & thermal generation forecast as determined by YECSIM:
  - Table 3.4-1 is based on YECSIM model simulation
  - GRA load applied to this table results in forecast thermal generation.
  - This generation results in forecast fuel expense for revenue requirement.

Application of YECSIM in 2017/18 GRA

Proposed DCF Table for 2017/18 GRA [Table 3.4-1]

Line Number	YEC Grid Load Net of Wind (GWh)	YEC Hydro Generation (GWh)	YEC Thermal Generation (GWh)	Increase in Load (GWh)	Increase in Thermal Generation (GWh)	Thermal as % of Increased Load
	Column A	Column B	Column C	Column D	Column E	Column F = E/D
1	370.0	369.337	0.663			
2	375.0	373.626	1.374	5.0	0.710	14%
3	380.0	377.800	2.200	5.0	0.826	17%
4	385.0	381.845	3.155	5.0	0.955	19%
5	390.0	385.750	4.250	5.0	1.096	22%
6	395.0	389.503	5.497	5.0	1.246	25%
7	400.0	393.098	6.902	5.0	1.405	28%
8	405.0	396.528	8.472	5.0	1.570	31%
9	410.0	399.789	10.211	5.0	1.739	35%
10	415.0	402.877	12.123	5.0	1.911	38%
11	420.0	405.793	14.207	5.0	2.084	42%
12	425.0	408.537	16.463	5.0	2.256	45%
13	430.0	411.111	18.889	5.0	2.426	49%
14	435.0	413.521	21.479	5.0	2.590	52%
15	440.0	415.772	24.228	5.0	2.748	55%
16	445.0	417.874	27.126	5.0	2.898	58%
17	450.0	419.836	30.164	5.0	3.038	61%
18	455.0	421.669	33.331	5.0	3.167	63%
19	460.0	423.388	36.612	5.0	3.281	66%
20	465.0	425.007	39.993	5.0	3.380	68%
21	470.0	426.545	43.455	5.0	3.462	69%
22	475.0	428.019	46.981	5.0	3.525	71%
23	480.0	429.452	50.548	5.0	3.567	71%
24	485.0	430.865	54.135	5.0	3.587	72%

Application of YECSIM in 2017/18 GRA
Proposed DCF Table for 2017/18 GRA [Table 3.4-1]

Table 3.4-1 steps to determine LTA thermal generation for a given load [e.g., 417 GWh]:

- ✓ **Step 1:** Find the closest load in Column A that is less than given load (i.e., 415 GWh)
- ✓ **Step 2:** Find the thermal generation from Column C = 12.123 GWh
- ✓ **Step 3:** Difference between given load (417 GWh) and load from Step 1 (415 GWh) = 2 GWh
- ✓ **Step 4:** Apply % from Column F to difference from Step 3 = 0.841 GWh
- ✓ **Step 5:** Add Step 2 (12.123 GWh) and Step 4 (0.841 GWh) = 12.963 GWh

Expected thermal generation at 417 GWh load is 12.963 GWh

Application of YECSIM in 2017/18 GRA
DCF Determinations [Table 3.4.1]

Table 3.4-1 Used During & After GRA Process

- ✓ Based on YECSIM model runs
- ✓ Provides LTA hydro & thermal for range of grid loads for Board approval

GRA Filing Test Year Forecasts

- *Tab 2, Table 2-2*
- *Provides thermal generation requirement for forecast generation load for each test year*

DCF Filing Final Assessments After GRA

- *Annual DCF Filing*
- *Used to determine expected thermal generation for actual grid load at each year end*
- *YECSIM model not re-run for DCF determinations*